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INCIDENCE, SEVERITY, AND GROWTH LOSSES
ASSOCIATED WITH PONDEROSA PINE DWARF MISTLETOE
ON THE SANTA FE NATIONAL FOREST,
NEW MEXICO

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ABSTRACT

Forest stands adjacent to 381.5 miles of forest road were surveyed on the Santa Fe National Forest in 1985 to determine the incidence and severity of dwarf mistletoe infection in the commercial ponderosa pine forest cover type. The survey data provided a basis for estimating the magnitude of growth losses associated with dwarf mistletoe. Thirty-five percent of the surveyed stands were mistletoe infected. Of the infected stands, 17 percent had less than one-third of the trees in the managed age class infected, 7 percent of the infected stands had one-third to two-thirds of the trees infected, and 11 percent of the stands had more than two-thirds of the trees in the managed age class infected. Forest-wide, 6,104 acres were surveyed; survey miles and acres were distributed proportionally across all stand size and visual quality classes. Chi-square analyses indicated that there were several significant relationships between stand size classes, visual quality classes, and dwarf mistletoe incidence and severity in the District and Forest-wide analyses.

A previous Region-wide dwarf mistletoe survey, conducted between 1954-57 (Andrews and Daniels 1960), indicated that 41 percent of the ponderosa pine stands on the Santa Fe National Forest were infected with dwarf mistletoe. Results from the 1985 survey indicate that dwarf mistletoe incidence is 6 percent less than was reported from the previous survey; however, nearly 50 percent of the commercial acres have been reclassified since that time. At present, dwarf mistletoe incidence on the Forest is equal to the Regional average.

Total growth losses were estimated using incidence and severity data from the 1985 survey and RMYLD2 growth and yield simulations. When timber management, silviculture, and dwarf mistletoe control were simultaneously optimized in the simulations, the most conservative estimate of annual loss in sawtimber at the current level of incidence was 7.0 MMBF per year. The corresponding annual loss estimate in pulpwood yield was 1.4 MMCF per year. Small changes in data input into RMYLD2 reflecting changes in timber management emphasis (i.e., focus on nontimber resource objectives), silvicultural prescriptions, and dwarf mistletoe control cutting methods, produced large increases in the annual loss estimates. Delayed stand entries produced equally large increases in the annual loss estimates. We estimate the annual losses in sawtimber growth and yield to be 14 to 21 MMBF and 3 to 4 MMCF, respectively.

INTRODUCTION

Rocky Mountain ponderosa pine (Pinus ponderosa var. scopulorum engelm.) grows on an estimated 11 million acres in the Southwestern United States. In Arizona and New Mexico, 2.5 million acres are regarded as being commercially productive (growth $\geq$ 20 cubic feet per acre per year). On the Santa Fe National Forest, 41 percent of the acres of commercial timberland are in the ponderosa pine forest cover type.

Region-wide, over one-third (36%) of the commercial ponderosa pine resource is dwarf mistletoe infected (Arceuthobium vaginatum subsp. cryptopodum (Engelm.) Hawks. and Wiens); by Forest, estimates of infection levels range from 15 percent to 64 percent (Andrews and Daniels 1960). Volume losses associated with ponderosa pine dwarf mistletoe are primarily growth losses. By comparison, losses caused by other important disease pests of ponderosa pine, most notably the root rot pathogens Armillaria sp. and Heterobasidion annosum, are related to tree mortality.

The apparent increase in incidence and severity of dwarf mistletoe in southwestern ponderosa pine has been of particular concern to forest pathologists. Observations suggest that stands with histories of repeated selective harvest exhibit the greatest increase in dwarf mistletoe infection severity; data to confirm or disprove this contention have been lacking. The objectives of this evaluation were to: (1) Compare present dwarf mistletoe incidence in the ponderosa pine forest cover type with that found in the 1954-57 survey on the Santa Fe National Forest, (2) determine if changes in dwarf mistletoe incidence and severity are related to stand size class or visual quality classifications, and (3) estimate annual growth losses caused by ponderosa pine dwarf mistletoe by Ranger District and Forest-wide.

METHODS

Roadside Survey. This evaluation used the survey methods of Andrews and Daniels (1960), Merrill et al. (1985), and Johnson et al. (1984). Roadside survey-sampling methods were deemed appropriate to this problem analysis, since the spread of dwarf mistletoe is not correlated with the presence or impact of forest roading.

The survey determined dwarf mistletoe incidence and severity by combinations of forest cover type, stand size class, and visual quality class. All passable National Forest System roads on each Ranger District were surveyed. Mistletoe data were collected only from acres of ponderosa pine classified as tentatively suitable in the land management planning process. Forest cover type and stand size class of stands adjacent to roads were determined from land management planning forest cover type maps. The 16 original stand condition classes (FSH 2409.26d, dated November 1975) were condensed for simplification to form 5 broader stand size classes:

Seedlings and saplings (SS); combining 01, 14, and 15
(>4 inches tall; <5.0 inches d.b.h.)

Poletimber (PT); combining 02, 04, 06, 08, 10, and 12
(5.0 to 8.9 inches d.b.h.)

Sawtimber (ST); combining 03, 05, 07, 09, and 13
(9.0 inches and larger)

Overmature timber (OT); 11
(old growth)

Nonstocked (NS); 16

Sensitivity levels and visual quality objectives (FSM 2382.21; Agriculture Handbook No. 462; FSM 2383.4) were combined to reduce the number of classes, since management practices do not change significantly between some levels. The seven combined classes were:

1. Foreground Retention (FR)
2. Other Retention (OR)
3. Foreground Partial Retention (FPR)
4. Level 3 Partial Retention (3PR)
5. Other Partial Retention (OPR)
6. Level 3 Modification (3M)
7. Other Modification (OM)

Visual resource inventory maps (scale 2.64 or 2.0 inches = 1 mile) were used to indicate current boundaries of visual quality areas. Changes in forest cover type, stand size class, and visual quality class were clearly marked on survey maps and those maps are archived as a permanent record of the survey. Two-person crews drove selected roads at speeds not exceeding 10 miles per hour and observed a strip 2 chains wide, measured from the edge of the right-of-way, parallel to the right side of the road. Changes in forest cover type, stand size class, visual quality class, and dwarf mistletoe infection severity were visually estimated and recorded to the nearest 0.10 mile using the survey vehicles' odometer. Dwarf mistletoe (DM) infection severity was measured as follows:

DM0 = No visible infection in stands.

DM1 = Less than one-third of the trees in the managed age class infected.

DM2 = One-third to two-thirds of the trees in the managed age class infected.

DM3 = More than two-thirds of the trees in the managed age class infected.

At the beginning of the survey, transects 1 chain wide by 2 chains long, perpendicular to the road axis, were established every mile in which infected and uninfected trees in the managed age class were tallied to correct ocular estimates of infection severity. The number of transects gradually decreased as survey crews developed expertise in estimating infection severity.

Survey results were expressed as the ratio of miles traveled adjacent to infected stands to the total miles traveled Forest-wide, by District, stand size class, visual quality class, and dwarf mistletoe infection severity level. A record of the roads surveyed and direction traveled for each road can be found in Figures 6-10 of the Appendix.

Growth Loss Estimations. If all stands on the Forests were mistletoe free, that would represent full volume productivity or potential. It is not now, nor will it ever be, feasible to reach the mistletoe free state. It is feasible, however, to reduce mistletoe infection severity in stands so that impact on full volume productivity is negligible. The comparison of full productive potential to existing conditions is useful for assessing the magnitude of the problem. In generating sawtimber and pulpwood volume loss estimates, stands representative of the three stand size classes (i.e., seedlings and saplings, poletimber, and sawtimber, were projected to rotation age (120 years) using RMYLD2 (Edminster 1978) at the midpoint of each of the four infection severity levels.

Each stand size class was assigned a nominal age:

Seedlings and Saplings	= 20 years
Poletimber	= 50 years
Sawtimber	= 100 years

Site index values of 60, 70, and 80 feet (100-year index age) were used in the growth and yield simulations to reflect the range of conditions extant on the Forest. Growing stock levels (GSLs) were adjusted whenever possible to reflect site productivity, optimize volume production and product size, and achieve effective dwarf mistletoe control. Differences in yield for stands managed to rotation at each infection severity level represented the impact on volume production attributable to dwarf mistletoe. RMYLD2 output was expressed in yield per acre; losses were assessed by subtracting infected from healthy stand yields. Losses are reported for each District surveyed by stand size class. Acres of tentatively suitable forest land by forest cover type and stand size class were obtained from the 1985 Draft Forest Plan and were also extrapolated from the survey. From the Forest Plan the total acres of commercial ponderosa pine = 216,867 acres.

Commercial acres by stand size class:

Seedlings and Saplings = 9,450 acres (4%)

Poletimber = 12,992 acres (6%)

Sawtimber = 194,425 acres (90%)

Seedling, sapling, and poletimber stands were managed to a 120-year rotation age beginning at 20 and 50 years, respectively. For sawtimber stands, future growth losses to dwarf mistletoe were considered minor since stand regeneration was imminent. The understory seedling and sapling component was managed to rotation on RMYLD2. The underlying assumption used in sawtimber simulations was equivalent infection levels in the overstory and understory components. Optimum silvicultural prescriptions by site index, stand size class, and dwarf mistletoe infection severity level are shown in Tables 1 and 2.

For all RMYLD2 simulations, dwarf mistletoe infection severity levels were set at the midpoint of their range:

DMO = no infection = PINF 0 ; DMLEV = 3.0

DM1 = 16.5 percent infection = PINF 16.5; DMLEV = 3.0

DM2 = 49.5 percent infection = PINF 49.5; DMLEV = 3.0

DM1 = 82.5 percent infection = PINF 82.5; DMLEV = 6.0

(PINF is the equivalent RMYLD2 input variable)

To arrive at estimates of potential volume production for DM3 = 82.5 percent infection, DMLEV was set at 6.0 (DMLEV is the input variable in RMYLD2 that indicates the dwarf mistletoe rating (DMR) above which thinnings will not be performed (Edminster 1978; Hawksworth 1977)).

RESULTS

Dwarf mistletoe was found in 35 percent of the ponderosa pine stands on the Santa Fe National Forest (Figure 1). Of the 381.5 miles surveyed, 132.3 miles were mistletoe infected. A total of 6,104 acres were surveyed, equal to a 3 percent sampling intensity. Dwarf mistletoe incidence and severity equaled the Regional average. Table 3 shows dwarf mistletoe incidence and severity by stand size class and District. Mistletoe incidence was greatest on the Las Vegas and Espanola Districts and least on the Cuba District. On the Las Vegas and Espanola Districts, 65 percent of the poletimber stands were mistletoe infected; 78 percent of the poletimber stands were infected on the Pecos District. Similarly, infection severity was much higher in sawtimber stands on each of these three Districts.

Table 4 shows mistletoe infection severity combining all stands in each District; it is a condensation of Table 3. Mistletoe incidence on the Cuba, Coyote, and Jemez Districts was beneath the average for the Forest; however, infection severity appears to be increasing on the Jemez District. Table 5 shows dwarf mistletoe incidence by visual quality class, and Table 6 gives incidence by visual quality class and infection severity level. Mistletoe was unevenly distributed with respect to visual quality classes on the Jemez District. Dwarf mistletoe incidence was less in foreground retention stands, and greater in other partial retention stands. On the Coyote District, mistletoe incidence was greatest in stands of any age that were classified as level 3 modification. On the Espanola District, mistletoe incidence was high in foreground partial retention and level 3 modification stands of any age, and infection severity appears to be increasing (Table 6). Forest-wide incidence in level 3 modification stands was 39 percent; on the Pecos, Espanola, and Las Vegas Districts, incidence was 51, 60, and 59 percent respectively. Forest-wide incidence in foreground partial retention was 29 percent; on the Espanola and Las Vegas Districts, incidence was 50 and 75 percent, respectively. In foreground retention stands, Forest-wide incidence was 19 percent; on the Pecos and Espanola Districts, incidence was 59 and 86 percent, respectively.

Chi-square analyses, comparing observed and expected mistletoe infection levels by stand size and visual quality classes, revealed several significant (P=0.05) relationships (Table 7 and Figures 2 and 3). On the Jemez District, mistletoe incidence was less than expected in foreground retention stands and greater than expected in other partial retention stands. Incidence in Pecos poletimber was greater than was predicted by the Chi-square distribution, and this difference was significant. Incidence in Pecos seedlings and saplings was less than was predicted from that same distribution. Forest-wide, mistletoe incidence was much less than expected in foreground retention stands, foreground partial retention stands, and seedling and sapling stands, and greater than expected in poletimber stands.

Estimates of annual growth loss by District are summarized in Table 8. These estimates are not based on simulating current management conditions, but are an expression of growth losses to dwarf mistletoe under the best circumstances, when silviculture and dwarf mistletoe control are optimized coincidentally and all infected stands are entered immediately. A sawtimber loss estimate of 7.0 MMBF per year, Forest-wide, is the most conservative estimate when mistletoe incidence is 35 percent (Figure 4). Since all stands cannot be entered immediately, current sawtimber losses on the Santa Fe National Forest exceed 14 MMBF per year and may run as high as 21 MMBF per year. This is confirmed in yield projections that allow delayed entry. A comparable inflation applies to cubic foot volume losses as well (i.e., 3-4 MMCF per year).

DISCUSSION

Based on the results of their 1954-57 mistletoe survey, Andrews and Daniels (1960) concluded that 41 percent of the commercial ponderosa pine stands on the Santa Fe National Forest were infected with dwarf mistletoe. These estimates were based on plot and roadside surveys; 227 plots were taken on the Forest and the results of the roadside survey were not published. We analyzed the data from the roadside survey and found that it corroborated the results of the plot survey for the Districts they surveyed. When that survey was conducted, 408,000 acres of ponderosa pine were considered suitable for commercial timber production and mistletoe incidence was related to that landbase. Since that time the commercial landbase in ponderosa pine has been reduced by nearly 50 percent to its present level of 216,867 acres; nearly 200,000 acres of Site II and III sawtimber were reclassified. Most of the acres that are presently classified as suitable for commercial production of ponderosa pine were part of the commercial landbase at the time of the Andrews and Daniels survey.

The results of the 1985 dwarf mistletoe survey indicate that forest-wide mistletoe incidence is 35 percent. We speculate that the 6 percent reduction in mistletoe incidence from the previous survey is an artifact of the land reclassification.

The current dwarf mistletoe problem on the Santa Fe National Forest is worthy of considerable attention, especially since the level of incidence is easily regulated, in most cases, with appropriate cutting methods. Management objectives should reflect a concerted effort to reduce dwarf mistletoe effects on growth and yield. Unchecked, the present mistletoe problem will worsen and the magnitude of associated growth losses will increase.

In general, dwarf mistletoe spreads most slowly in single-story, even-aged stands of any age. Small departures from even-aged management result in radical increases in dwarf mistletoe incidence and severity. In the RMYLD2 growth and yield simulations that were used to estimate volume losses, stocking was drastically reduced in infected stands at the earliest possible time to reduce stand DMR's. Without this early reduction in stocking, stands were destroyed by dwarf mistletoe before rotation age. Volume loss estimates assume that thinning entries or regeneration cuts were made in every stand at the most opportune time. Departures from this management strategy resulted in reductions in timber yield much worse than reported here.

In addition to documenting mistletoe incidence, severity, and associated growth losses, it is intended that these survey results will draw to a focus the scope and principal causes of the mistletoe problem, so that corrective timber management decisions can be made to reduce the current level of incidence on the Forest.

The principal causes as we see them are:

1. A repeated history of selective harvesting in dwarf mistletoe-infected stands.

2. Silvicultural prescriptions that perpetuated uneven-aged stand conditions. The ponderosa pine cover type consisted of a mosaic of uneven-aged clumps of trees. Following selective overstory removals, portions of every stand were naturally regenerated. Seed cuts were rare and total overstory removals almost nonexistent.

3. Lack of priority given to treating mistletoe-infected stands. Entire timber sale areas were selectively harvested to produce a targeted volume. Little thought was given to delineating specific cutting units for the primary purpose of controlling dwarf mistletoe. By giving mistletoe-infected stands high treatment priority in timber sales, two major works could be accomplished: (a) The targeted volume could be realized from fewer acres and (b) greater volume would be produced in properly treated stands that could be harvested in subsequent entries.

4. Ineffective cutting methods when dwarf mistletoe was the intended object of silvicultural prescriptions. Visibly infected overstory trees were removed, but trees with little evidence of witches broom formation were retained in the overstory. Seeds discharged from mistletoe plants in the residual overstory trees provided the inoculum source for further overstory and understory infections. In most cases, a seed cut and overstory removal, followed by judicious thinning in the understory, would have reduced the presence of the dwarf mistletoe in stands to acceptable levels.

5. Lack of consistency in controlling dwarf mistletoe in stands of any size class. Table 3 shows the breakdown of dwarf mistletoe infection severity by size class; Table 7 shows the increments and decrements. In Table 3, mistletoe incidence in seedling and sapling stands is 34 percent less than the Forest-wide mistletoe estimate; incidence in sawtimber stands is equal to the Forest-wide estimate. In poletimber stands mistletoe incidence is 3 percent greater than Forest-wide.

6. Lack of consistency in controlling dwarf mistletoe in stands of any visual quality class. Table 6 shows the breakdown of dwarf mistletoe infection severity by visual quality class; Table 7 indicates the increments and decrements. The most visually sensitive visual quality class and least impacted by timber management entries is the foreground retention class. We might expect that dwarf mistletoe incidence in these stands would be greatest because they are not entered for management to retain their visual integrity. On the contrary, dwarf mistletoe incidence is lowest in foreground retention stands. We surmise that the lack of timber management entries in these stands has reduced or eliminated the potential for mistletoe

enhancement by selective harvesting. In visual quality classes where considerable stand modification is allowed or acceptable, mistletoe incidence consistently exceeds the Forest-wide average.

The growth losses estimated and presented reflect the level of damage and loss associated with mistletoe at the present level of incidence. Losses will decrease with reductions in the number and distribution of infected trees in stands. The solution to the problem lies in improving stand management by treating infected stands first, thereby reducing mistletoe incidence in stands, one stand at a time. It is important that mistletoe incidence routinely becomes a major decision variable when stand treatments are prioritized and cutting units are selected in timber sales. Prescriptions need to reflect a major emphasis of reducing stand DMR, while trying to reflect stocking, spacing, and tree diameter objectives. Dwarf mistletoe is endemic in southwestern ponderosa pine forests, but its impact can be reduced with proper management so that the effects are negligible.

Chapter 70 in the Cutting Methods Handbook (FSH 2409.26a, dated December 1984) was prepared as a field aid for dealing with mistletoe-infected stands. Information is given on rating infected trees and whole stands, and methods are presented which aid in the complex process of determining which cutting units should be entered and which can be deferred. Sections on regeneration and intermediate cutting methods are also included. Much of the time these materials will provide the necessary guidance. If additional technical assistance is needed, pathologists in the Regional Office are available to help evaluate mistletoe problems and assist in formulating prescriptions to control dwarf mistletoe in specific cutting units.

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APPENDIX

TABLE 1.—Optimum prescriptions for RMYLD2 growth and yield simulations for the Santa Fe National Forest seedlings and saplings (SS).

SSC[1]	AGE (YRS)	SITE INDEX	DMR[2] START (0-6)	PINF[2] START %	DMR[3] FINAL (0-6)	THIN1[2] (GSL)	DSTY1[2] (GSL)	DSTY2[2] (GSL)	DBH[3] CUT (IN)	DBH[3] RESID. (IN)	VOLUME OUT[3] MBF/AC	VOLUME OUT[3] MCF/AC	CULM. MAI[4] AGE (YRS)	CULM. MAI[4] FT[3]
SS	20	60	0	0	0	60	60	60	18.5	16.6	16.5	3.6	110	28
			0.2	16.5	0.1	30	60	60	18.5	16.6	15.3	3.4	100	26
			0.7	49.5	0.1	20	40	40	21.5	19.7	12.1	2.5	120	20
(Regenerate)[5]			2.6	82.5	6.0	20	20	20	21.3	21.3	0.6	0.1	70	8
SS	20	70	0	0	0	70	70	70	18.6	16.7	22.5	4.8	110	37
			0.2	16.5	0.1	40	70	70	18.6	16.7	21.6	4.6	100	35
			0.7	49.5	0.1	20	40	40	22.4	20.7	15.0	3.0	100	24
(Regenerate)[5]			2.6	82.5	5.5	20	20	20	23.5	23.4	4.3	1.0	80	12
SS	20	80	0	0	0	80	90	90	18.1	16.2	32.1	6.6	100	51
			0.2	16.5	0.1	50	80	80	18.8	16.9	28.8	5.9	100	46
			0.7	49.5	0.1	30	60	60	20.8	19.1	23.8	4.8	100	37
(Regenerate)[5]			2.6	82.5	4.8	20	20	20	26.0	25.8	8.8	1.8	100	16

[1]SSC is stand size class.

[2]Input variables for data entry into RMYLD2; DMR START=DMR(1) stand dwarf mistletoe rating; PINF START=PINF(1) percent mistletoe infected; THIN1=growing stock level achieved with initial thinning; DSTY1 and 2=growing stock level or density achieved with subsequent entries. (Edminster 1978)

[3]Output from RMYLD2; DMR FINAL=stand dwarf mistletoe rating at rotation; DBH CUT=average diameter of sawtimber cut during the seed cut; DBH RESID.=average seed tree diameter; VOLUME OUT=commercial volume produced per acre.

[4]Culmination of mean annual increment.

[5]Unable to reduce dwarf mistletoe to acceptable levels; regenerate the stand.

TABLE 2.--Optimum prescriptions for RMYLD2 growth and yield simulations for the Santa Fe National Forest poletimber (PT).

SSC[1]	AGE (yrs)	SITE INDEX	DMR[2] START (0-6)	PINF[2] START %	DMR[3] FINAL (0-6)	THIN1[2] (GSL)	DSTY1[2] (GSL)	DSTY2[2] (GSL)	DBH[3] CUT (in)	DBH[3] RESID. (in)	VOLUME OUT[3] MBF/AC	VOLUME OUT[3] MCF/AC	CULM.MAI[4] AGE (yrs)	CULM.MAI[4] ft³
PT	50	60	0	0	0	60	70	70	16.8	15.0	16.6	3.6	110	28
			0.2	16.5	0.1	60	60	60	16.9	15.1	14.2	3.5	110	27
			0.7	49.5	0.1	40	50	50	17.4	15.6	12.3	3.1	110	24
(Regenerate)[5]			2.6	82.5	3.9	20	20	20	20.3	19.6	5.8	1.7	70	13
PT	50	70	0	0	0	70	80	80	17.2	15.4	22.0	4.7	110	36
			0.2	16.5	0.1	70	70	70	17.4	15.6	20.3	4.6	110	35
			0.7	49.5	0.1	50	60	60	17.8	16.0	17.8	4.2	110	32
(Regenerate)[5]			2.6	82.5	3.2	20	20	20	21.5	20.6	7.2	2.1	70	18
PT	50	80	0	0	0	80	90	90	18.0	16.2	30.0	6.2	120	48
			0.2	16.5	0.1	60	80	80	17.4	15.6	25.6	5.9	110	46
			0.7	49.5	0.1	60	80	80	17.4	15.6	25.6	5.9	110	46
(Regenerate)[5]			2.6	82.5	2.7	20	30	30	20.9	19.7	11.9	3.4	70	27

[1]SSC is stand size class.

[2]Input variables for data entry into RMYLD2; DMR START=DMR(1) stand dwarf mistletoe rating; PINF START=PINF(1) percent mistletoe infected; THIN1=growing stock level achieved with initial thinning; DSTY1 and 2=growing stock level or density achieved with subsequent entries. (Edminster 1978)

[3]Output from RMYLD2; DMR FINAL=stand dwarf mistletoe rating at rotation; DBH CUT=average diameter of sawtimber cut during the seed cut; DBH RESID.=average seed tree diameter; VOLUME OUT=commercial volume produced per acre.

[4]Culmination of mean annual increment.

[5]Unable to reduce dwarf mistletoe to acceptable levels; regenerate the stand.

TABLE 3.--Dwarf mistletoe infection severity estimates by stand size class for Districts on the Santa Fe National Forest.

		STAND SIZE CLASS															
		SEEDLINGS/SAPLINGS				POLETIMBER				SAWTIMBER				OVERMATURE			
RANGER DISTRICT		0	1	2	3[1]	0	1	2	3	0	1	2	3	0	1	2	3
CUBA	MI[2]	0.1	0	0	0	27.4	4.1	4.9	2.9	30.5	5.1	3.3	4.9	5.7	0	0	0
	%[3]	100				70	10	12	8	70	12	8	11	100			
COYOTE	MI	0.3	0	0	0	19.0	7.4	2.0	0.6	60.2	17.9	5.9	5.9				
	%	100				66	26	7	2	67	20	7	7				
JEMEZ	MI	6.5	0	0	0	23.1	4.3	0.9	5.9	46.1	11.0	3.9	7.5	0.2	0	0	0
	%	100				68	13	3	17	67	16	6	11	100			
PECOS	MI	6.6	0.2	0	0	2.8	5.1	2.7	2.1	7.4	2.2	2.3	1.9	0.8	0	0	0
	%	97	3			22	40	21	17	54	16	17	14	100			
ESPANOLA	MI	0.6	0	0	0	0.8	1.0	0	0.5	7.4	2.1	1.1	6.4	0.6	0	0	0
	%	100				35	43		22	44	12	6	38	100			
LAS VEGAS	MI	0	0	0	0	0.8	1.4	0.1	0	2.3	1.8	1.0	1.7	0	0.3	0	0
	%					35	61	4		34	26	15	25		100		
FOREST TOTAL	MI	14.1	0.2	0	0	73.9	23.3	10.6	12.0	153.9	40.1	17.5	28.3	7.3	0.3	0	0
	%	99	1			62	19	9	10	64	17	7	12	96	4		

[1] Dwarf mistletoe infection severity level.

[2] Miles of road surveyed in stands of a particular size class and infection severity level.

[3] Percentages are computed within the stand size for a single District, and are rounded up to nearest whole percentage.

TABLE 4.--Comparison of dwarf mistletoe infection severity levels between Districts on the Santa Fe National Forest.

RANGER DISTRICT		DWARF MISTLETOE INFECTION SEVERITY					
		DM(-)[1]	DM(+)[2]	DM1[3]	DM2[3]	DM3[3]	SUBTOTAL
CUBA	MI[4]	63.7	25.2	9.2	8.2	7.8	88.9[5]
	%[6]	72	28	10	9	9	23[7]
COYOTE	MI	79.5	39.7	25.3	7.9	6.5	119.2[5]
	%	67	33	21	7	5	31[7]
JEMEZ	MI	75.9	33.5	15.3	4.8	13.4	109.4[5]
	%	69	31	14	4	12	29[7]
PECOS	MI	17.6	16.5	7.5	5.0	4.0	35.1[5]
	%	52	48	22	15	12	9[7]
ESPANOLA	MI	9.4	11.1	3.1	1.1	6.9	20.5[5]
	%	46	54	15	5	34	5[7]
LAS VEGAS	MI	3.1	6.3	3.5	1.1	1.7	9.4[5]
	%	33	67	37	12	18	2[7]
FOREST TOTAL	MI	249.2	132.3	63.9	28.1	40.3	381.5
	%	65	35	17	7	11	100

[1](-)=Miles of ponderosa pine stands surveyed without dwarf mistletoe infection.

[2](+)=Miles of ponderosa pine stands surveyed with dwarf mistletoe infection of severity level (1, 2, or 3).

[3]Dwarf mistletoe infection severity level.

[4]Miles surveyed in stands within a District and infection severity level.

[5]Miles surveyed in a District.

[6]Percentage of total miles surveyed in a District with infection severity level.

[7]Percentage of Forest-wide survey miles.

TABLE 5--Dwarf mistletoe incidence by visual quality class for Districts on the Santa Fe National Forest.

		FR[1]		FPR[1]		OPR[1]		3M[1]		SUBTOTAL	
RANGER DISTRICT	DM	(-)[2]	(+)[3]	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)
CUBA	MI[4]	11.2	1.2	23.1	11.0	0.4	0	29.0	13.0	63.7	25.2
	%[5]	90	10	68	32	100		69	31	72	28
COYOTE	MI	3.4	0.7	22.2	6.1	1.4	0	52.5	32.9	79.5	39.7
	%	83	17	78	22	100		61	39	67	33
JEMEZ	MI	24.7	1.9	16.7	1.9	7.1	13.3	27.4	16.4	75.9	33.5
	%	93	7	90	10	35	65	63	37	69	31
PECOS	MI	3.2	4.7	5.3	2.8	0.4	0	8.7	9.0	17.6	16.5
	%	41	59	65	35	100		49	51	52	48
ESPANOLA	MI			6.0	6.0			3.4	5.1	9.4	11.1
	%			50	50			40	60	46	54
LAS VEGAS	MI	0.2	1.2	0.6	1.8			2.3	3.3	3.1	6.3
	%	14	86	25	75			41	59	33	67
FOREST TOTAL	MI	42.7	9.7	73.9	29.6	9.3	13.3	123.3	79.7	249.2	132.3
	%	81	19	71	29	41	59	61	39	65	35

[1] Visual quality classes, no OR, 3PR, or OM classes were surveyed (see page 4 for an explanation of abbreviations).

[2] (-)=Surveyed stands without dwarf mistletoe infection.

[3] (+)=Surveyed stands with dwarf mistletoe infection of severity level 1, 2, or 3.

[4] Miles of road surveyed in stands within a District, in a given visual quality class.

[5] Percentage of total miles of road surveyed within a District, in a given visual quality class.

TABLE 6.—Comparison of dwarf mistletoe infection severity estimates by visual quality class for Districts on the Santa Fe National Forest.

RANGER DISTRICT		FR[1] 0	FR[1] 1	FR[1] 2	FR[1] 3[2]	FPR[1] 0	FPR[1] 1	FPR[1] 2	FPR[1] 3	OPR[1] 0	OPR[1] 1	OPR[1] 2	OPR[1] 3	3M[1] 0	3M[1] 1	3M[1] 2	3M[1] 3
CUBA	MI[3]	11.2	1.0	0.2		23.1	4.3	2.9	3.8	0.4				29.0	3.9	5.1	4.0
	%[4]	90	8	2		68	13	9	11	100				69	9	12	10
COYOTE	MI	3.4	0.5	0.1	0.1	22.2	2.9	1.7	1.5	1.4				52.5	21.9	6.1	4.9
	%	83	12	2	2	78	10	6	5	100				61	26	7	6
JEMEZ	MI	24.7	1.2	0.2	0.5	16.7	1.1		0.8	7.1	3.4	2.5	7.4	27.4	9.6	2.1	4.7
	%	93	5	1	2	90	6		4	35	17	12	36	63	22	5	11
PECOS	MI	3.2	2.7	1.2	0.8	5.3	1.1	1.4	0.3	0.4				8.7	3.7	2.4	2.9
	%	41	34	15	10	65	14	17	4	100				49	21	14	16
ESPANOLA	MI					6.0	0.6	0.2	5.2					3.4	2.5	0.9	1.7
	%					50	5	2	43					40	29	11	20
LAS VEGAS	MI	0.2	0.4	0.8		0.6	1.5	0.2	0.1					2.3	1.6	0.1	1.6
	%	14	29	57		25	63	8	4					41	29	2	29
FOREST TOTAL	MI	42.7	5.8	2.5	1.4	73.9	11.5	6.4	11.7	9.3	3.4	2.5	7.4	123.3	43.2	16.7	19.8
	%	81	11	5	3	71	11	6	11	41	15	11	33	61	21	88	10

[1]Visual quality class, no OR, 3PR, or OM classes were surveyed (see page 4 for an explanation of abbreviations).

[2]Dwarf mistletoe infection severity level.

[3]Miles of road surveyed in stands of particular size class and infection severity level.

[4]Percentages are computed within the stand size for a single District, and are rounded up to nearest whole percentage.

TABL --Summary of Chi-square analyses comparing obs . and expected mistletoe incidence[1] by stand size classes and visual quality classes (P=0.05).

		STAND SIZE CLASSES				VISUAL QUALITY CLASSES			
RANGER DISTRICT		SS[2]	PT[2]	ST[2]	OT[2]	FR[3]	FPR[3]	OPR[3]	3M[3]
CUBA (O_1-E_1)	MI[4]	0	+0.9	+1.0	-1.6	-2.3	+1.4	-0.1	+1.2
	SIG[5]	NS	NS	NS	NS	NS	NS	NS	NS
COYOTE	MI	-0.1	+0.4	0		-0.7	-3.2	-0.5	-4.7
	SIG	NS	NS	NS		NS	NS	NS	NS
JEMEZ	MI	-2.0	+0.5	+1.2		-6.4	-3.9	+7.0	2.8
	SIG	NS	NS	NS		S	NS	S	NS
PECOS	MI	-3.1	+3.8	-0.2	-0.4	+0.9	-1.1	-0.2	+0.5
	SIG	S	S	NS	NS	NS	NS	NS	NS
ESPANOLA	MI	-0.3	+0.3	+0.4	-0.3		-0.5		+0.5
	SIG	NS	NS	NS	NS		NS		NS
LAS VEGAS	MI		0	-0.1	+0.1	+0.3	+0.2		-0.5
	SIG		NS	NS	NS	NS	NS		NS
FOREST TOTAL	MI	-4.8	+4.0	+2.0	-2.4	-8.6	-6.6	+5.4	+8.6
	SIG	S	S	NS	NS	S	S	S	S

[1] Dwarf mistletoe incidence is presented as miles of stands surveyed with any mistletoe infection, by stand size class, visual quality class, and District.

[2] SS=seedling and sapling stands; PT=poletimber stands; ST=sawtimber stands; OT=overmature stands.

[3] See page 4 for an explanation of abbreviations, no OR, 3PR, or OM classes were surveyed.

[4] Difference between the observed (O_1) number of miles of road surveyed with mistletoe infection and the expected (E_1) number of miles with mistletoe infection as predicted by the Chi-square distribution.

[5] Denotes significance at P=0.05; NS is not significant; S is significant.

TABLE 8.--Minimum estimate[1] of annual losses in sawtimber and poletimber production on the Santa Fe National Forest.

		POLETIMBER (PT)		SAWTIMBER (ST)		SUBTOTAL	
RANGER DISTRICT		MMBF/YR	MMCF/YR	MMBF/YR	MMCF/YR	MMBF/YR	MMCF/YR
CUBA	VOL.	0.3	0.0+	1.4	0.3	1.7	0.3
	%[2]	18		82		24	
COYOTE	VOL.	0.0+	0.0+	1.2	0.2	1.2	0.2
	%			100		17	
JEMEZ	VOL.	0.1	0.0+	1.5	0.3	1.6	0.3
	%	6		94		23	
PECOS	VOL.	0.0+	0.0+	1.0	0.2	1.0	0.2
	%			100		14	
ESPANOLA	VOL.	0.0+	0.0+	1.1	0.2	1.1	0.2
	%			100		16	
LAS VEGAS	VOL.	0.0+	0.0+	0.4	0.1	0.4	0.1
	%			100		6	
FOREST	VOL.	0.4	0.1	6.6	1.3	7.0	1.4
TOTAL	%	6		94		100	

[1] Estimates based on RMYLD2 growth and yield projections using incidence severity data from the survey.

[2] Percentage of District losses in a stand size class.

FIGURE 1. Comparison of DM incidence between Districts on the Santa Fe National Forest

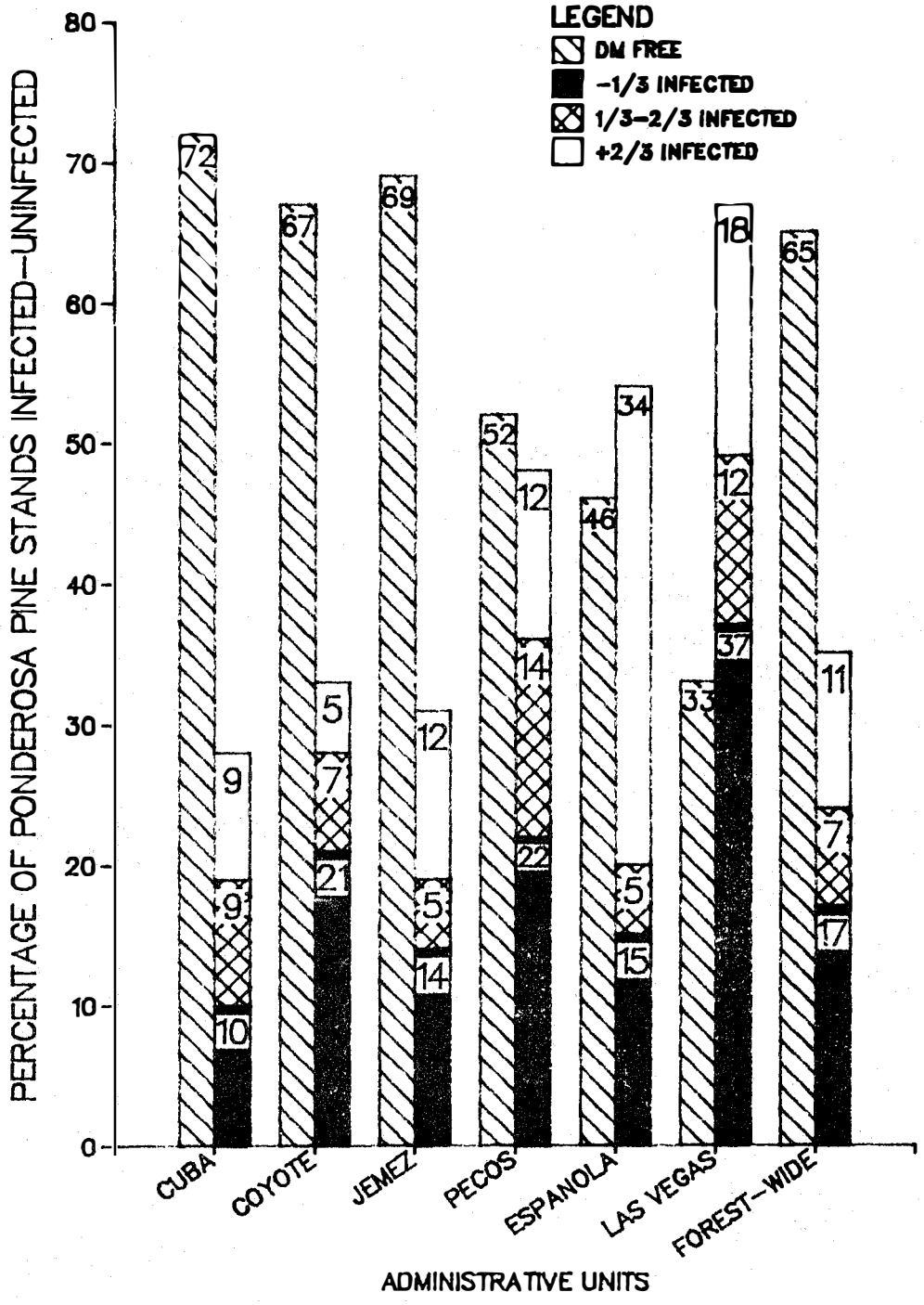


FIGURE 2. Comparison of observed and expected DM incidence by size class for the Santa Fe National Forest

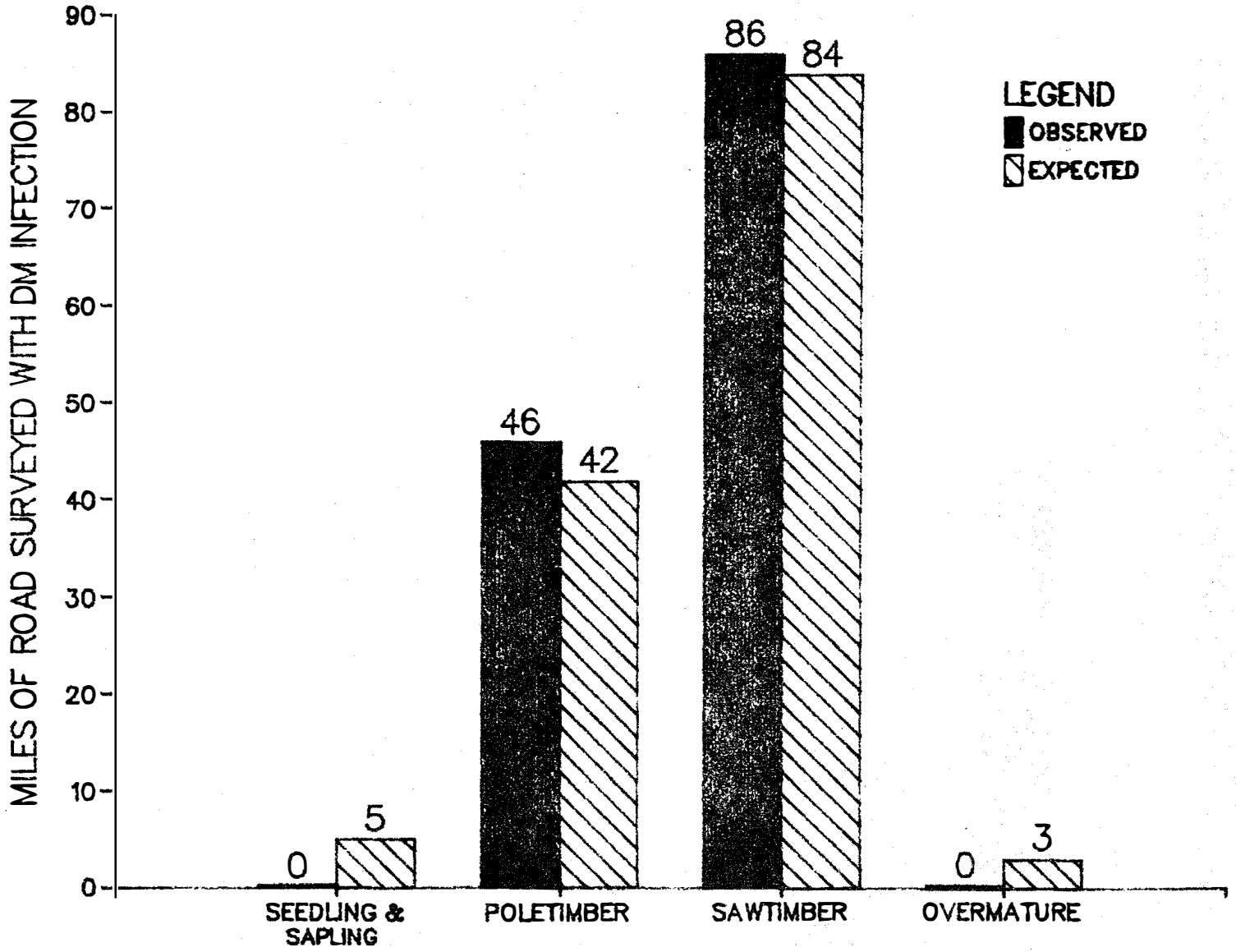


FIGURE 3. Comparison of observed and expected DM incidence by visual quality class for the Santa Fe National Forest

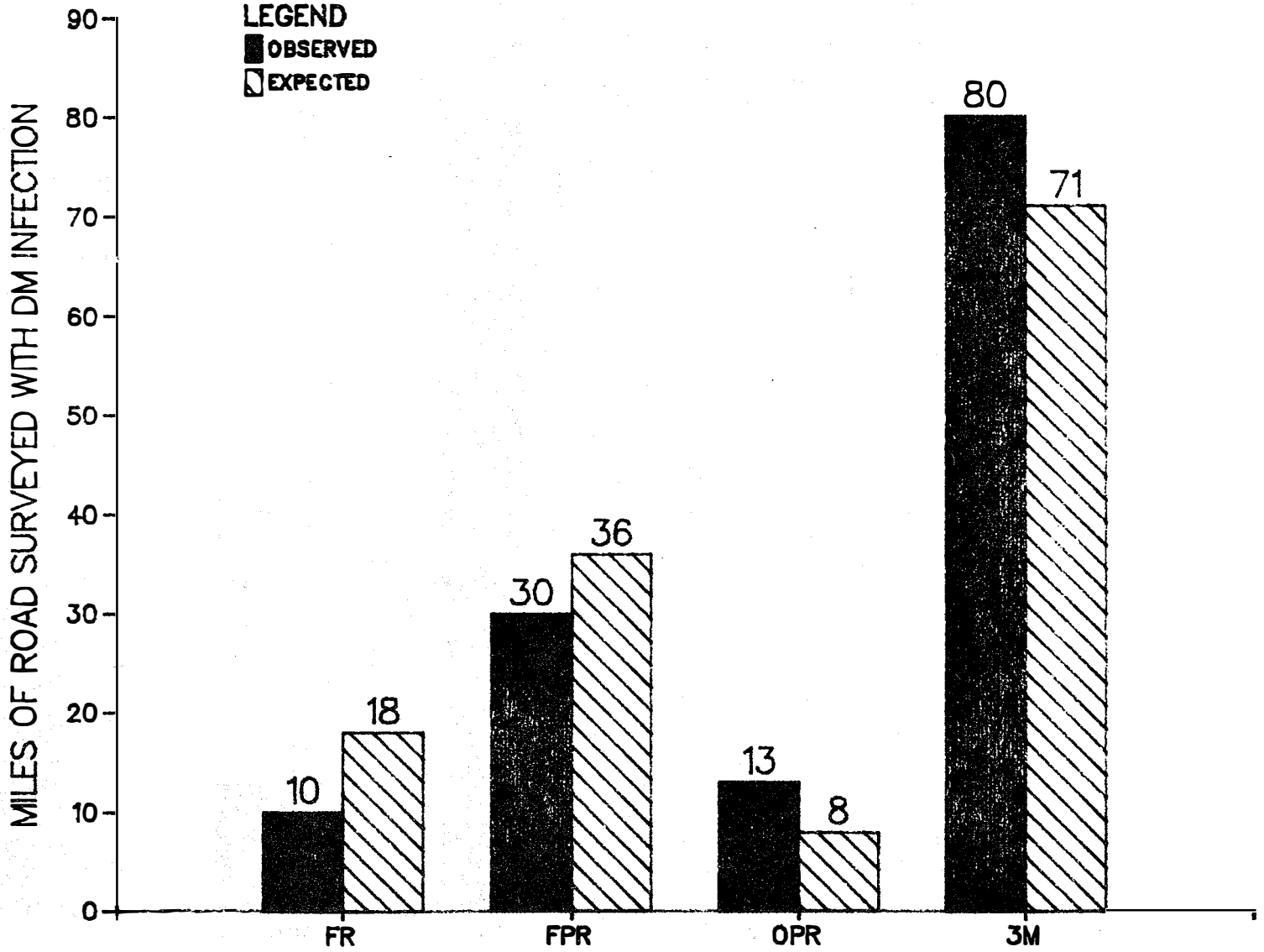


FIGURE 4. Distribution of projected annual volume losses by size class for the Santa Fe National Forest

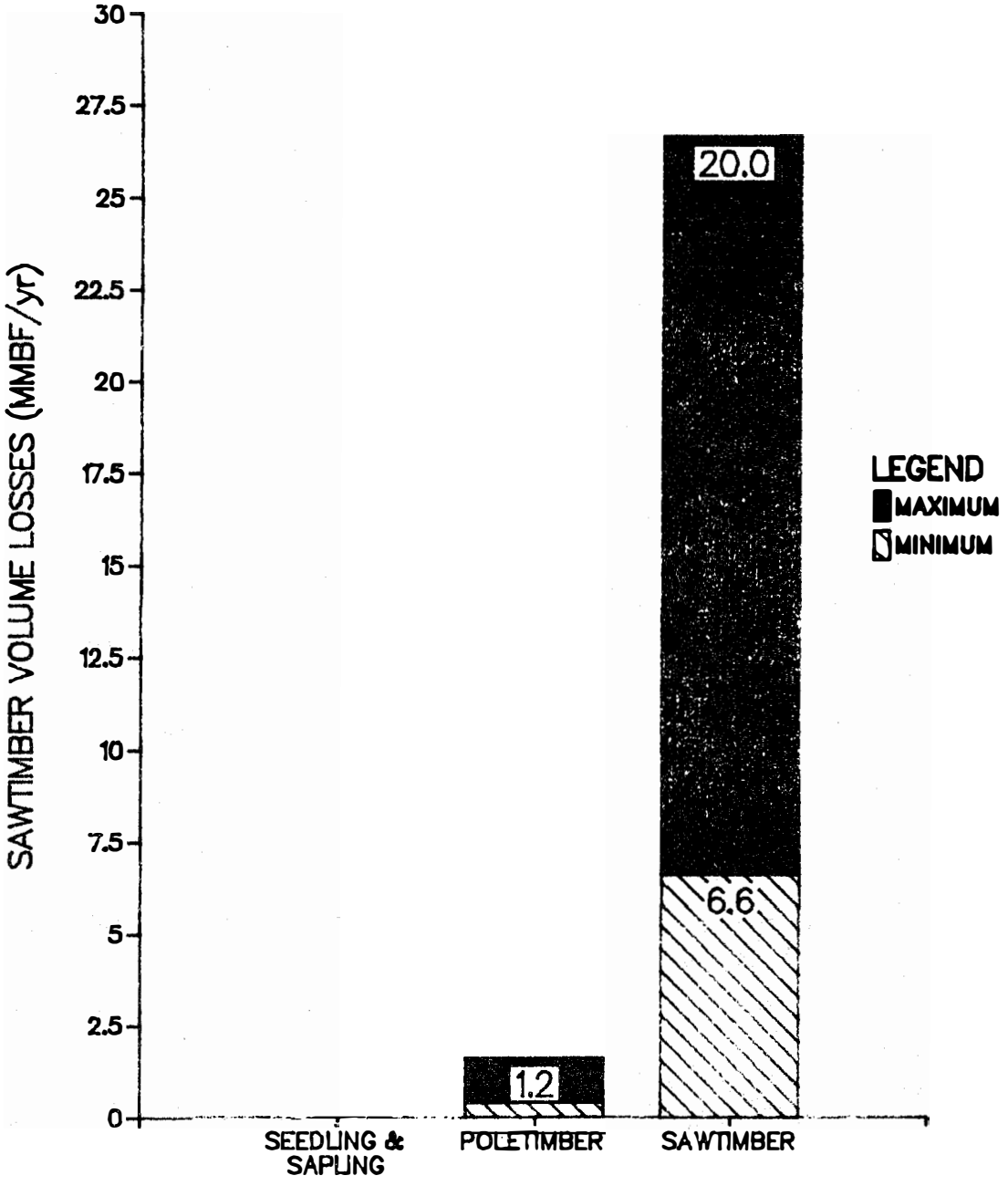
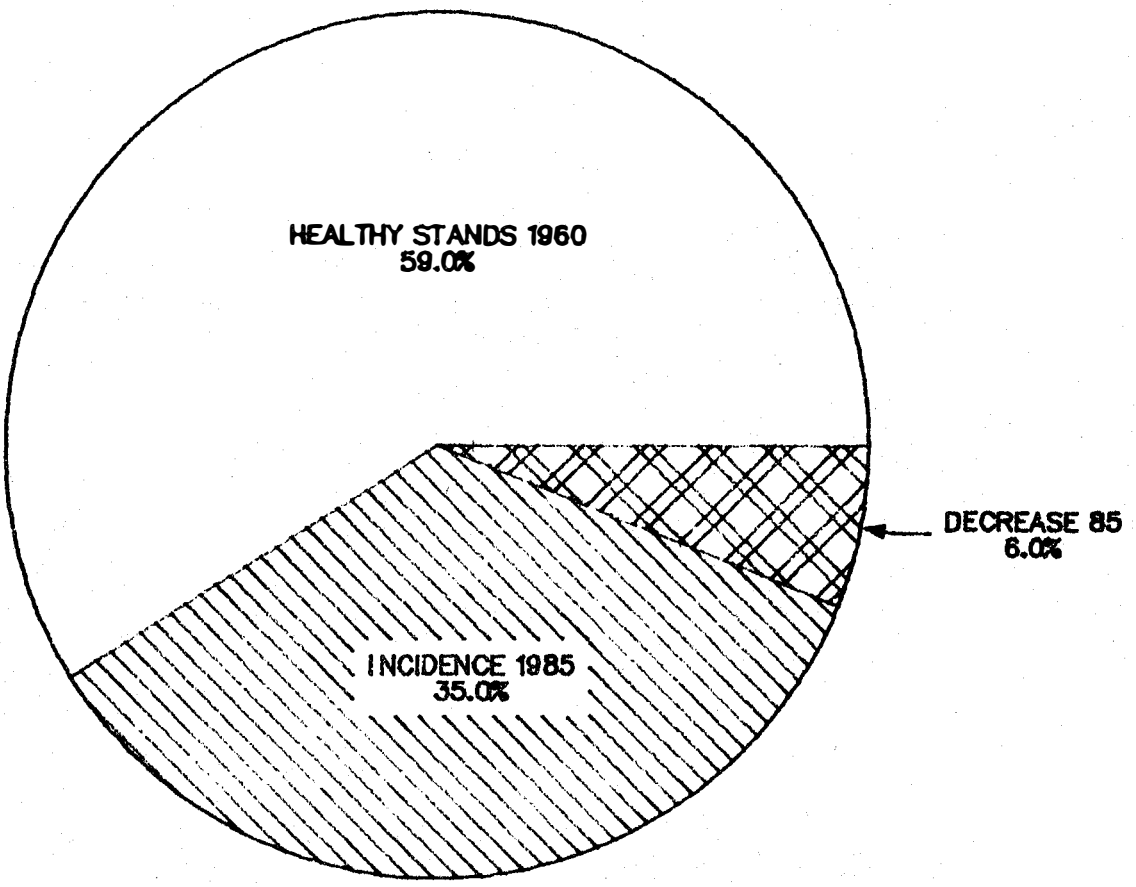


FIGURE 5. Decrease in dwarf mistletoe incidence in commercial ponderosa pine stands on the Santa Fe National Forest from 1960--1985



PROPORTION OF TOTAL NO. OF STANDS

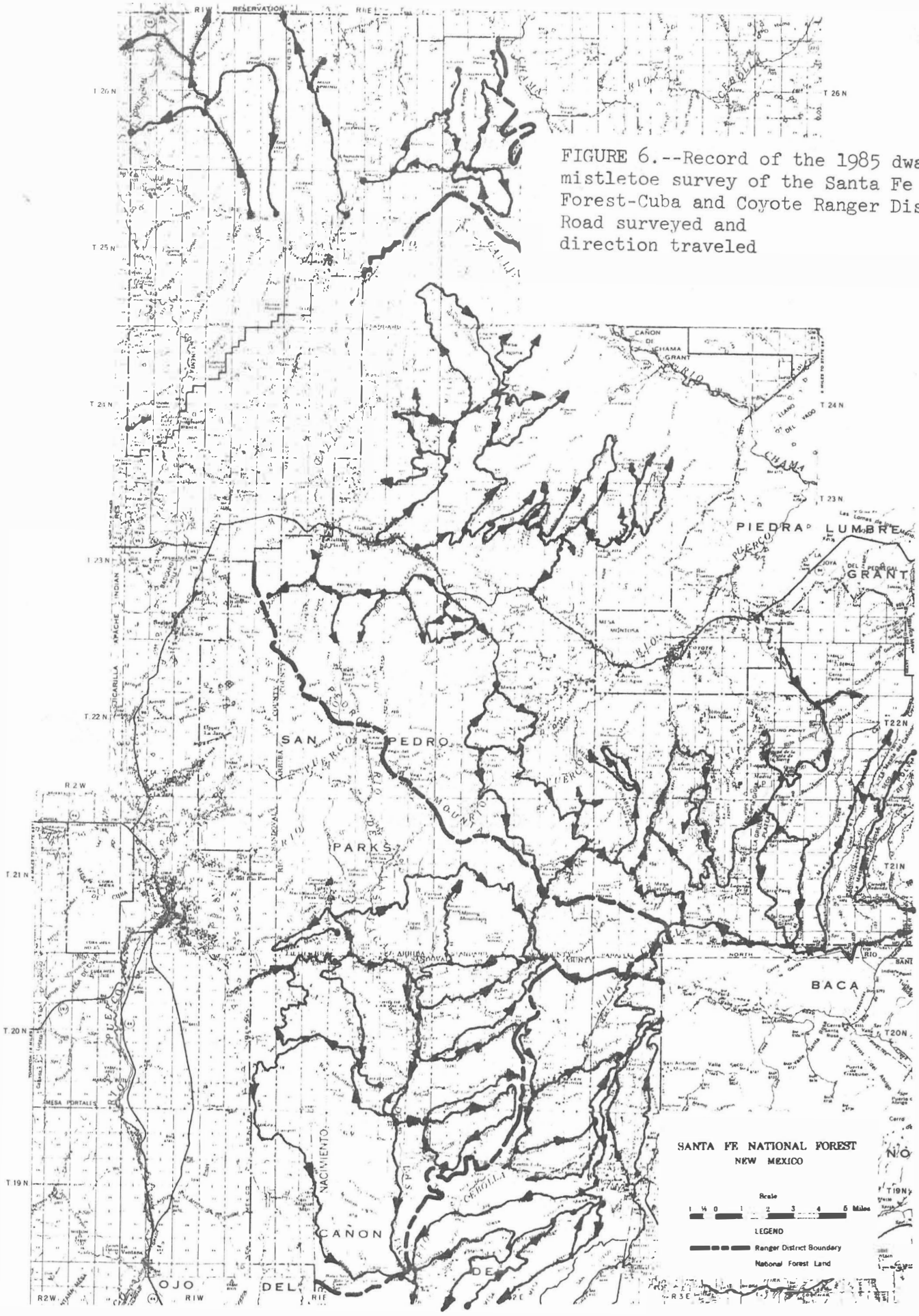


FIGURE 6.--Record of the 1985 dwarf mistletoe survey of the Santa Fe National Forest-Cuba and Coyote Ranger Districts. Road surveyed and direction traveled

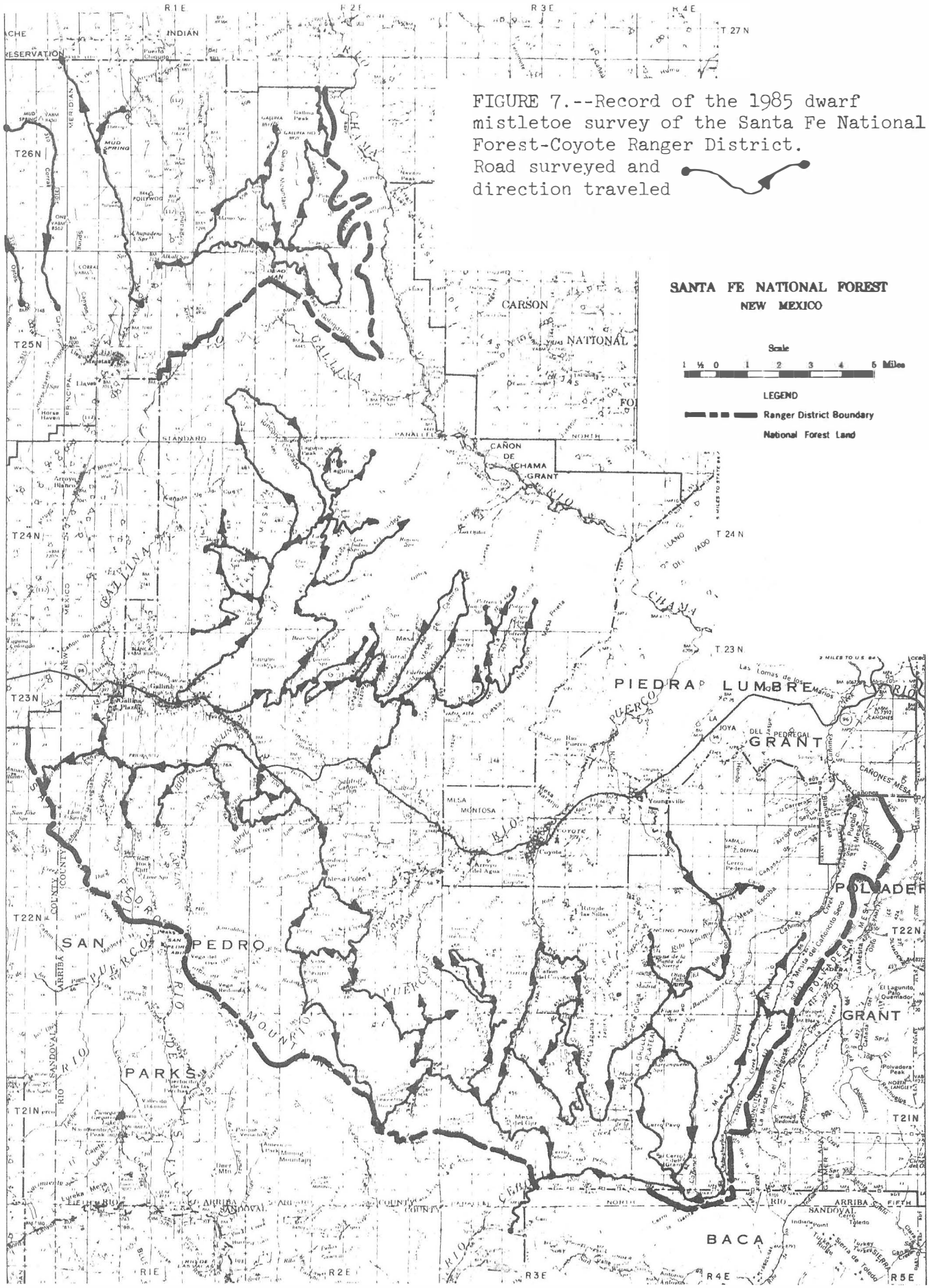


FIGURE 7.--Record of the 1985 dwarf mistletoe survey of the Santa Fe National Forest-Coyote Ranger District. Road surveyed and direction traveled

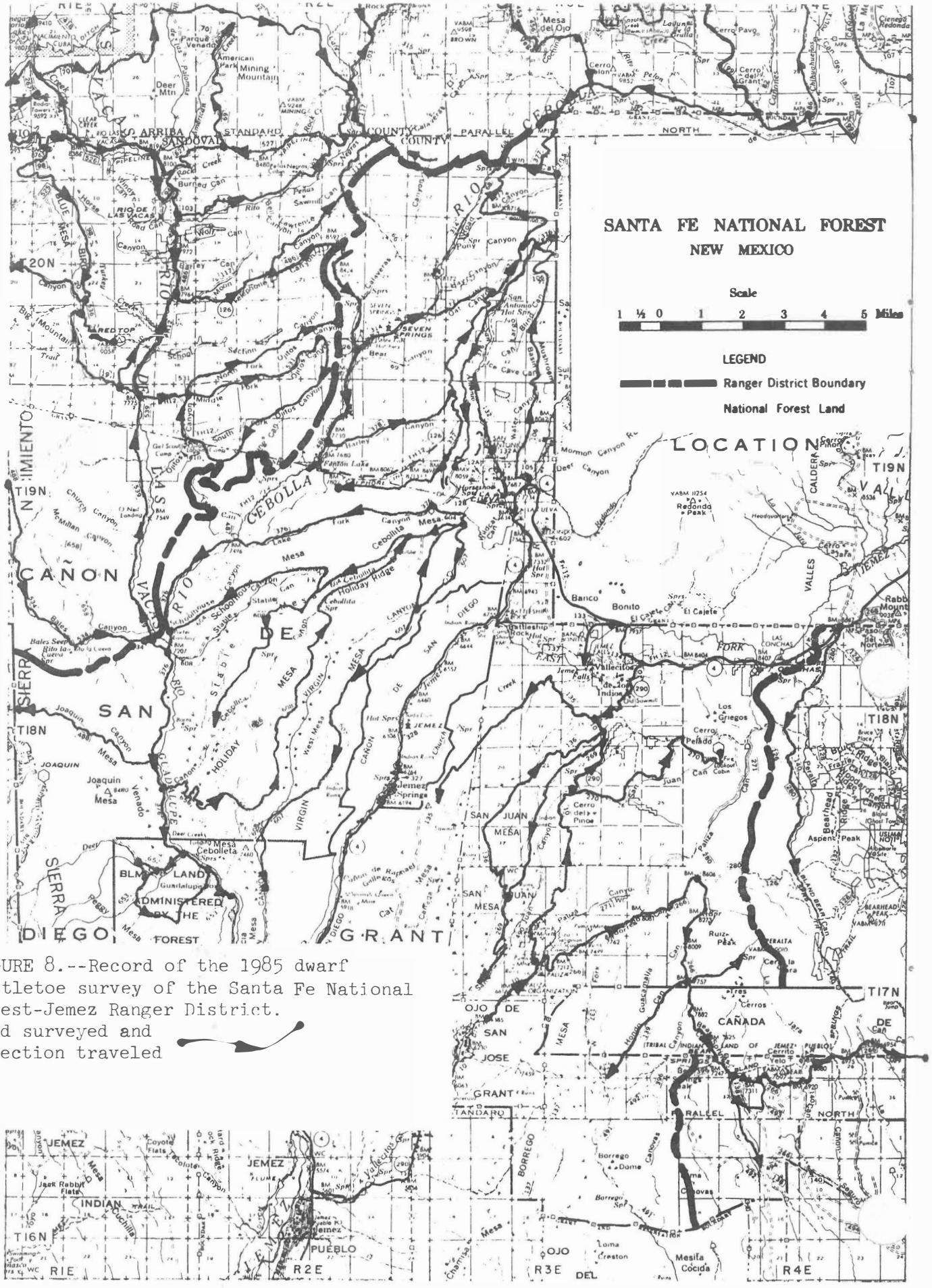


FIGURE 8.--Record of the 1985 dwarf mistletoe survey of the Santa Fe National Forest-Jemez Ranger District. Road surveyed and direction traveled

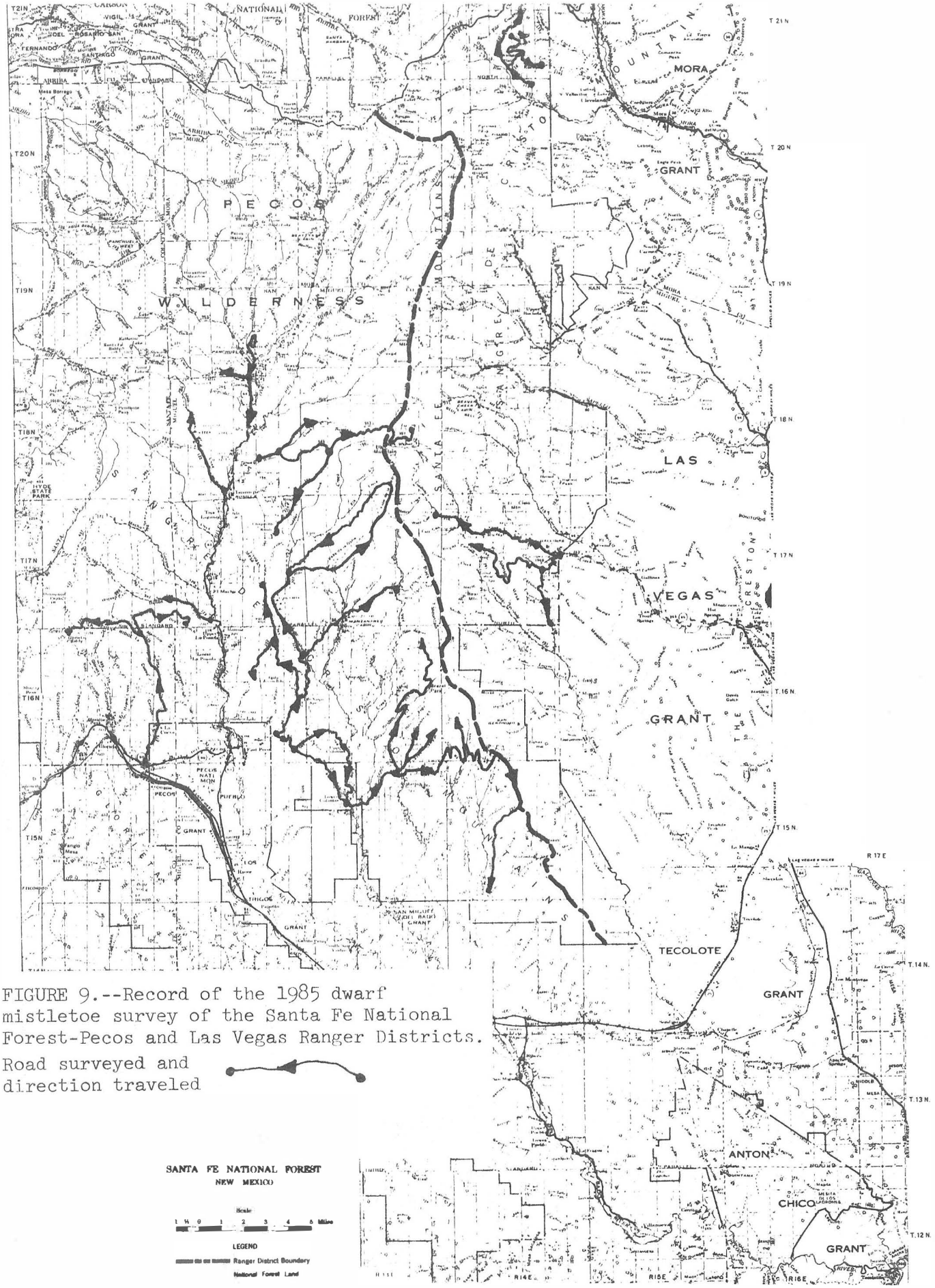


FIGURE 9.--Record of the 1985 dwarf mistletoe survey of the Santa Fe National Forest-Pecos and Las Vegas Ranger Districts.

Road surveyed and direction traveled

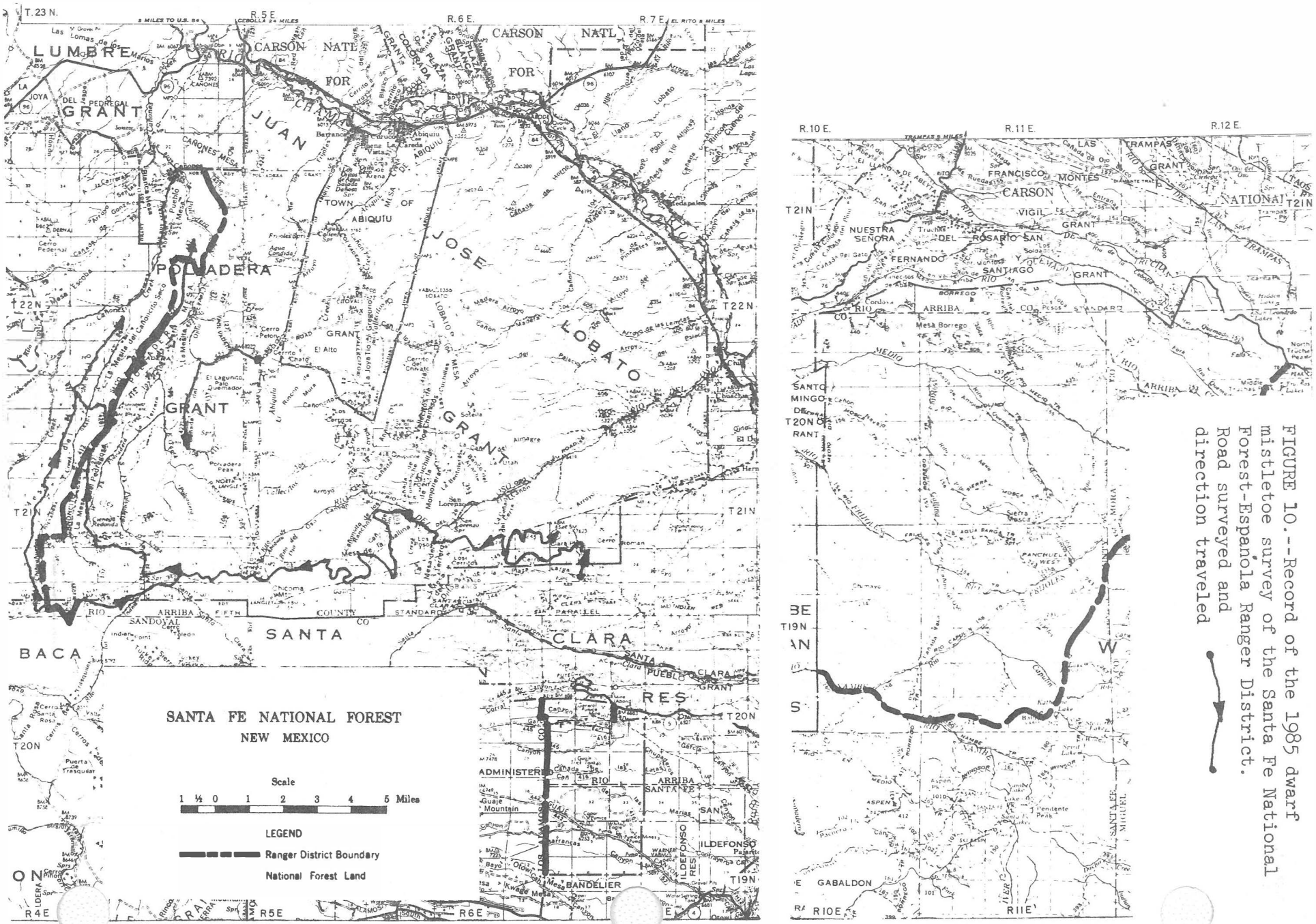


FIGURE 10.--Record of the 1985 dwarf mistletoe survey of the Santa Fe National Forest-Española Ranger District. Road surveyed and direction traveled